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ABSTRACT

The theory of reasoned action is a social psychological model that was first considered by science educators in the early 1980s to investigate attitude-behavior relationships. The theory has encouraged intense investigations in the prediction of behavior, development of instruments, and creation of belief-based interventions. This investigation examined 21 studies guided by the theory of reasoned action or theory of planned behavior. These research reports were scrutinized for common and discrepant outcomes as well as improvements to procedures and instrumentation. Assertions were constructed by the researchers from the findings revealed in the reports. Triangulation efforts involved having persons who conducted the studies to react to assertions generated from the written reports. Results of this study indicate that the majority of studies used regression analysis to identify behavioral determinants and by so doing contributed to an understanding of factors that motivate students and teachers to act as they do. Other studies used the tenets of the theoretical models to construct interventions to impact the determinants of science-related behaviors. All contributed in some way to the refinement of instruments used to measure the determinants of action. Thus, assertions were grouped under three main headings: (1) behavioral prediction and understanding; (2) intervention design and implementation; and (3) measurement of model variables. (PR)

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Attitude-Behavior Change in Science Education: Part II, Results of an Ongoing Research Agenda

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Introduction

Researchers have for some time studied the science-related behaviors of students and teachers and the factors that promote and inhibit their occurrence. But only recently have theoretical models become available to help direct these efforts by showing how attitude and behavior are systematically related. One of these models is Fishbein and Ajzen's (1975) theory of reasoned action. In his treatise on the relationship between attitude and behavior, Shrigley (1990) described the theory of reasoned action as "one of the...major thrusts in attitude research today." Studies based on the theory of reasoned action and its recent corollary the theory of planned behavior (Ajzen, 1985) are to a great extent shielded from two criticisms leveled at attitude research in science education—absence of theoretical framework and flawed measurement.

The usefulness of these theories to science educators is based on three considerations. They abet the understanding and prediction of behavior. The models direct the development of instruments to measure variables that function as determinants of behavior. They also guide the creation of belief-based interventions. In short, Fishbein and Ajzen's theoretical models have served to encourage intense investigation in an area that had seemed to reach an impasse only a few years ago.

Purpose

The purpose of this work was to identify overarching assertions from the findings of studies conducted by a like-minded cadre of researchers over a period of more than five years. The findings focus on critical science-related decisions made by teachers and students and factors, both internal and external to the decision maker, that prompted the actions. The strength of the assertions lie in the studies' theoretical grounding in that all were guided by the theory of reasoned action or the theory of planned behavior. Central to the findings are the concepts of belief, attitude, social and situational constraints, motivation, and behavior.

Procedures

Twenty-one studies guided by the theory of reasoned action or theory of planned behavior were located. Written reports of these studies constituted the primary data base. These reports were carefully scrutinized for common and discrepant outcomes as well as improvements to procedures and instrumentation. Assertions were constructed by the researchers from the findings revealed in the reports. Triangulation efforts involved having persons who conducted the studies to react to assertions generated from the written reports.

The researchers' bias stem from their direct involvement in many of the studies examined. Direct involvement implies a vested interest and may result in interpretations that highlight the strengths and downplay the failing of the studies and of the theories of reasoned action and planned behavior. On the other hand, close involvement in the studies allows for insights and interpretations not possible by those whose only source of information is the written reports.

Findings

The twenty-one studies reviewed dealt with numerous science-related behaviors ranging from enrollment in high school chemistry to use of science teaching methods introduced during a summer institute. (See Table 1.) The majority employed regression analysis to identify behavioral determinants and by so doing contributed to an understanding of factors that motivate students and teachers to act as they do. Other studies used the tenets of the theoretical models to construct interventions to impact the determinants of science-related behaviors. All contributed in some way to the refinement of instruments used to measure the determinants of action. Thus, assertions were grouped under three main headings: (1) behavioral prediction and understanding, (2) intervention design and implementation, and (3) measurement of model variables. Presented below are the assertions and supporting evidence related to each of these three areas.

Behavioral Prediction and Understanding.

Assertion 1: One's motivation to engage in a science-related behavior is

determined by attitude toward the behavior, significant referents, and situational pressures.

Central to the theory of reasoned action is the premise that the determinants of behavioral intention are attitude toward the behavior and subjective norm. Several studies tested this premise. The first to do so was conducted by Stead (13). He questioned New Zealand secondary students about studying science in the Fifth form. The study revealed that the contribution of attitude and subjective norm to the prediction of intention was highly significant for boys and girls. The two model variables in combination accounted for 65 percent of the variance in intention scores for boys and 88 percent for girls.

Studies in the U.S. focused on student enrollment in elective high school science courses. The association of elective science course enrollment with continued study in science and science-related career choices prompted this selection. Crawley and Coe (6) found that the combination of attitude and subjective norm accounted for 35 percent of the explained variance in students' intentions to enroll in elective high school science courses. In Koballa's (7) study of eighth grade boys and girls, attitude and subjective norm predicted intention to enroll in an elective physical science course, with the model variables in combination explaining 32 percent of the variance in intention scores. When studying only girls, Koballa (9) found that attitude and subjective norm combined to account for only 16 percent of the variance in their intentions to enroll in an elective physical science course.

Other studies employed the theory of reasoned action to investigate different science-related behaviors. Chen (15) reported that attitude and subjective norm accounted for about 50 percent of the variance in Chinese preservice teachers' intentions to teach about the environment during their first year of employment, while Goddard's (18) study of nursing students' intentions to care for quadriplegic patients found that attitude and subjective norm combined to explain 27 percent of the variance in intention. In a study of Korean high school students' track choice for college entrance, Myeong (10) reported that the combination of attitude and subjective norm accounted for 71 percent of the variance in

students' intentions to choose the science track over the humanities track. The focus of Ray's (11) work was students' intentions to perform laboratory and nonlaboratory science activities, and his subjects were public school children enrolled in grades three to eight. Multiple regression analysis revealed that "attitude toward the behavior and subjective norm predicted a significant amount of the variance in intention for both laboratory and nonlaboratory behaviors" (p. 157). The amounts of variance explained, however, were rather low in comparison to those reported for other studied, according to Ray. Attitude and subjective norm in combination explained 14 percent and 25 percent of the variance for the laboratory and nonlaboratory behaviors, respectively.

Crawley (3) used the variables of attitude, subjective norm, and perceived behavioral control in his study of teachers' intentions to use investigative science instructional methods. He found that the simultaneous contribution of the three variables to the prediction of intention was highly significant, accounting for 28 percent of the variance. This explained variance exceeded that accounted for by attitude and subjective norm alone by 4 percent. Unfortunately, this 4 percent difference was not found to be significant. Crawley also considered the interactions of the three model variables in addition to their independent contributions in predicting intention, but found that the explained variance was 4 percent less than when only the independent contributions of the three variables were considered.

High school and junior high students were the subjects of other studies that used the theory of planned behavior. Coleman, Koballa, and Crawley (16) investigated high school students' intentions to enroll in elective chemistry, physics, and courses taught using interactive video technologies. Their results showed that the contributions of the three model variables to the prediction of intention was highly significant, with the amount of explained variance averaging better than 50 percent for the three behaviors investigated. When studying the determinants of science and mathematics achievement among tenth-grade Palestinian girls, Arditzoglou (1) found that attitude and perceived behavioral control, but not subjective norm, contributed to the prediction of achievement intention. Warden (20)

found that attitude, subjective norm, and perceived behavioral control combined to explain 57 percent of the variance in junior high students' intentions to volunteer to be the laboratory partner of a classmate who has AIDS.

Hispanic-American students' intentions to enroll in elective high school chemistry were examined in two other studies. Black (14) found that attitude, subjective norm, and perceived behavioral control in combination explained 49 percent of the variance in students' intention scores, while Crawley and Koballa (17) reported that the model variables accounted for 48 percent of the variability in behavioral intention.

The theory of planned behavior was also used to predict college students' success in an introductory computer science course (12). Success was operationalized as a grade of C or better in the course, and data were collected at the beginning of the course and near its end. The study found that only 1 percent of the variance in students' intentions to succeed was explained by the independent contributions of the three model variables and their interactions at the beginning of the course, but near the end they accounted for 47 percent of the variance. Shaffer's explanation for the sharp contrast in variance accounted for was that only near the end of the course do students have accurate information regarding the likelihood of their success.

Assertion 2: Demographic characteristics and traditional measures of science attitude have no direct relationship to students' and teachers' motivation to engage in science-related behaviors.

In their theory of reasoned action, Ajzen and Fishbein (1980) described the influence of variables external to the model on behavior as affecting behavior indirectly and only through their influence on one or more of the variables specified by their theory. A number of science education studies examined the effect of demographic characteristics and attitude toward science on the behavioral intentions of students and teachers.

Besides the effect of attitude and subjective norm on students' intentions to enroll in elective high school science courses, demographic characteristics were considered in two

studies. One study looked at the influence of sex, ethnicity, general ability, and science ability (6). The subjects were eighth graders attending a single Texas school. It was revealed that only attitude and subjective norm contributed significantly to the prediction of intention. The prediction of intention was not improved when sex, ethnicity, science ability, or general ability were considered. In the second study (9), science grades and general ability were the external variables considered. Koballa's findings corroborate those reported by Crawley and Coe. General ability and science grades were found to be unrelated to the eighth grade girls' subjective norm, attitude, and intentions to enroll in at least one elective physical science course in high school. This study also revealed that attitude toward science as measured by the Wareing Attitude Toward Science Protocol was unrelated to the girls' intentions. Different from the findings of other studies, Myeong (10) reported that "gender and students' self-concept of performance in science, mathematics, and in general were significantly related to [Korean] students' track choice" (pp. 145-146).

One study utilized the theory of planned behavior to examine the influence of three variables external to the model in predicting intention. To attitude, subjective norm, and perceived behavioral control, Shaffer (12) added gender, ethnicity, and Scholastic Aptitude Test Quantitative scores to predict college students' success in an introductory computer science course. He found that the addition of these variables did not improve the prediction of behavioral intention beyond that possible when only the three model variables were considered.

In addition to demographic characteristics and personality traits, numerous measures of attitude toward science have been used to predict science-related behaviors. But as Willson's (1983) meta-analysis revealed, the relationships between these measures and the behaviors of interest were often much weaker than expected. Extrapolating from the theory of reasoned action, the reason for these weak relationships is that attitude and behavior were not measured at the same level of specificity. To test this proposition, Koballa (8) collected attitude and behavioral intention data from preservice teachers. While his measure of

behavioral intention remained constant, four measures of attitude were tested:

- target—attitude toward science (Wareing Attitude Toward Science Protocol)
- target and action—attitude toward science teaching (Thompson and Shrigley's Revised Science Attitude Scale)
- target, action, and context—attitude toward teaching science using hands-on activities at least twice a week (Investigator's construction)
- target, action, context, and time—attitude toward teaching science using hands-on activities at least twice a week during the student's first year of employment (Investigator's construction)

Each was selected because of its different degree of correspondence with the measure of intention. Koballa found that the predictability of the subjects' behavioral intentions from their attitudes improved as the degree of correspondence between the measures of attitude and behavioral intention increased. Only the measure of attitude toward science was not significantly related to intention. This finding suggests that behavioral prediction, as foretold by behavioral intention scores, is improved if the attitude measure is calibrated at the same level of specificity as the behavior.

Assertion 3: The importance of attitude toward the behavior, significant referents, and situational pressures in determining motivation varies among science-related behaviors and among students and teachers.

In studies based on the theory of reasoned action, subjective norm was considered simultaneously with attitude to predict intention. According the Ajzen and Fishbein (1980), the weighting of each variable, reported as a regression coefficient, reflects its independent contribution to prediction of intention. The relative contribution of these two variables in predicting behavioral intention was determined in two studies of preservice teachers. Koballa (8) found that college students' intentions to teach science using hands-on activities as first year teachers was more a factor of attitude toward the behavior than the influences of subjective norm. Chen (15) reported that attitude was a more important determinant of

Chinese perservice teachers' intentions to teach environmental science topics to young children than was subjective norm. He found that only attitude contributed significantly on the prediction of intention.

Other studies were also based on the theory of reasoned action. When investigating children's intentions to participate in laboratory and nonlaboratory science activities, Ray's (11) analysis showed that attitude contributed more to the prediction of intention for both behaviors than did subjective norm. Goddard (18) reported similar results for nursing students when questioned about their intentions to care for quadriplegic patients. Myeong's (10) study of Korean high school students' science track choice for college entrance used structural equation modeling with LISREL in addition to regression analyses. She found that attitude but not subjective norm contributed significantly to the prediction of behavioral intention.

In studies of students' intentions to enroll in elective high school science courses, attitude was also found to carried more weight in the multiple regression on intention that subjective norm (6, 7); although, both variables made significant contributions to the prediction of intention. Crawley and Coe also found that when their sample of 100 eighth graders was grouped by sex, ethnicity, general ability, and science ability the prediction of intention was generally improved, but differentially affected. For example, only attitude contributed significantly to the prediction of intention for low general ability students, both attitude and subjective norm contributed significantly for medium ability students, and only subjective norm did so for those high in general ability.

Other studies examined the relative contribution of the variables proffered by the theory of planned behavioral in predicting students' behavioral intentions. In studies of Hispanic-American students' intentions to enroll in high school chemistry, Black (14) found that attitude, subjective norm, and perceived behavioral control contributed significantly to the prediction of intention, while Crawley and Koballa (17) identified significant contributions for only attitude and perceived behavioral control. Crawley and Black (5) found that

students' intention to enroll in high school physics was dependent on attitude, subjective norm, and perceived behavioral control, but the contribution of each variable differed among the four grade levels tested. Warden (20) reported that only attitude and perceived behavioral control contributed significantly to seventh graders' intentions to work with a classmate who has AIDS. Likewise, Arditzoglou's (1) LISREL analysis revealed that both attitude and perceived behavioral control, but not subjective norm, influence female Palestinian students' science and mathematics achievement intention. All studies based on the theory of planned behavior found that attitude contributed more to the prediction of intention than either of the other two variables.

When studying teachers' intentions to use investigative science activities, Crawley (3) disaggregated his data by external variables to better understand the influence of the model variables on the subgroups that composed his sample. His results showed that the relative contributions of attitude and subjective norm are differentially affected when the sample is disaggregated. "Attitude was found to be the sole predictor of behavioral intention among female teachers..., elementary and secondary school teachers..., [and] teachers in the age range 24-33" (p. 692). Subjective norm was not the sole predictor of intention for any group formed on the basis of sex, level taught, or age. Finding that the theory of planned behavior did not improve the prediction of intention beyond that possible with the theory of reasoned action, Crawley used the teachers' perceived behavioral control scores as a blocking variable. This action revealed that both attitude and subjective norm were significant predictors of intention for teachers whose perceived behavioral control scores were high, and that attitude was the sole predictor of intention among teachers with low perceived behavioral control scores.

Shaffer (12) explored the predictive effects of the theories of reasoned action and behavioral control variables while studying students' success in a computer science course. He found that attitude was the sole predictor of intention when using the theory of reasoned action, but only near the end of the course. When considering the theory of planned

behavior variables, only perceived behavioral control contributed significantly to the prediction of intention near the end of the course.

Shaffer also disaggregated his data by external variables. Mixed results were reported for the beginning of the semester, with attitude, subjective norm, and perceived behavioral control contributing to the prediction of intention for females only. Statistically significant results were not found for males or groups formed on the basic of ethnicity or Scholastic Aptitude Test quantitative scores. However, the blocking variables were good predictors in many cases near the end of the semester. For example, attitude, subjective norm, and perceived behavioral control contributing to the prediction of intention for females, but the contribution of attitude was far less than for the other two variables for males. For Black students, subjective norm and perceived behavioral control contributed significantly to the prediction of intention, while attitude and subjective norm proved to be the best predictors of intention for White students. Subjective norm and perceived behavioral control were significant predictors of intention for students whose Scholastic Aptitude Test quantitative scores were above 585; however, all three model variables contributed significantly to the prediction of intention for students whose scores were below 445.

Assertion 4. Attitude toward the behavior, significant referents, and situational pressures are related to the sum of personal beliefs, normative beliefs, and control beliefs, respectively.

The true strength of the theoretical models is their ability to explain diverse human behaviors. The explanative power resides with the belief-based antecedents of attitude, subjective norm, and perceived behavioral control. The respective belief-based antecedents of these variables are personal beliefs and outcome evaluation, normative beliefs and motivation to comply, and control beliefs and likelihood of occurrence.

Several studies based on the theory of reasoned action reported statistically significant correlations between attitude and its belief-based antecedents and between subjective norm and its belief-based antecedents. The behaviors considered in these studies included

teaching energy conservation practices to young children (19), caring for quadriplegic patients (18), using investigative teaching methods (3), enrolling in elective high school science courses (9), participating in laboratory and non-laboratory science activities (11), studying science (13), and teaching Chinese children about the environment (15). Besides reporting correlations, the belief-based antecedents of attitude and subjective norm were identified in each study. For example, the consequences linked by Chinese preservice teachers with teaching children about the environment included gaining personal confidence about teaching environmental topics and preparing students who have a better understanding of the environment. School administrators, students, and their parents were seen as significant referents by the preservice teachers.

Studies based on the theory of planned behavior dealt with the belief-based antecedents of perceived behavioral control in addition to those for attitude and subjective norm. Warden (20) found that while the correlations between the direct measures of the three model variables and their corresponding antecedents were statistically significant, the correlation between the direct measure of perceived behavioral control and "its corresponding indirect salient counterpart" was weaker than that for the other two. Black (14) and Crawley and Koballa (17) reported findings similar to Warden's. The correlation between perceived behavioral control and its salient determinants was weaker than the correlations between attitude and subjective norm and their respective salient determinants. Only in Black's study was this relationship statistically significant. Different from the findings reported by others, Shaffer (12) found that the belief-based measures of subjective norm was not significantly correlated with its direct measures.

Crawley and Coe's (6) finding of a significant correlation between attitude and its belief-based determinant led them to conduct follow-up tests in order to "identify behavioral determinants (vis., belief strength, outcome evaluation, and the product of the two) that serve as bases for differences in the relative contributions of attitude to the prediction of intention for groups of students formed on the basis of membership in one of the categories

of each external variable—namely, sex, ethnicity, general ability, and science ability" (p. 472). Differences were found primarily between males and females, with the differences centering on their evaluations of the outcomes linked with enrolling in a high school science course. For example, reasons favored for enrolling in science by female, more so than males, include meeting new students, preparing for college, and learning new information. In contrast, males, more so than females, associate science enrollment with the perceived difficulty of science compared to other school electives.

When investigating teachers' use of physical science activities with their students, Crawley (3) found a significant correlation between the direct measure of attitude and its belief determinants. Follow-up tests carried out by Crawley involved groups formed on the basis of teachers' sex, school level, age, and level of perceived behavioral control. Many of the differences found distinguished between elementary and secondary teachers. For example, elementary teachers valued several outcomes more highly than did their secondary counterparts. Among them were giving students experience using physical science equipment and providing opportunities for students to interact with one another. Furthermore, elementary more so than secondary teachers associated use of the physical science activities with enabling them to teach physical science to students of differing interests and abilities, getting students more actively involved in learning physical science, and making physical science more interesting and fun.

To more accurately identify the belief-based antecedents of attitude, subjective norm, and perceived behavioral control, Crawley and Koballa (17) employed a procedure called theory trimming by Pedhazur (1982). According to Crawley and Koballa, theory trimming involves eliminating from the regression equation those variables that make nonsignificant contributions to the model effects. When studying the enrollment of Hispanic-American students in high school chemistry, the number of personal, normative, and control beliefs was reduced to six, five, and six respectively.

Following on Crawley and Koballa's heels, Black (14) and Shaffer (12) also used the

procedure. For Black, theory trimming increased the correlations between each of the three theory of planned behavior model variables and their respective antecedents by reduced the number of beliefs considered. The numbers of significant personal, normative, and control beliefs were reduced to five, three, and two, respectively. Shaffer reported that only two beliefs contributed significantly to the prediction of attitude, one belief contributed significantly to the prediction of subjective norm, and one to the prediction to perceived behavioral control. Since Shaffer dealt with students' intentions to succeed in an introductory computer science course, it is not surprising that beliefs about mastery of content material, family support, and one's own ability made statistically significant contributions.

Intervention Design and Implementation.

Assertion 5. Personal, normative, and control beliefs function as the basic elements of interventions to affect the occurrence of science-related behaviors.

Modal salient personal, normative, and control beliefs identified through a content analysis procedure have been used to design interventions to affect the occurrence of several science-related behaviors. Following from the theory of reasoned action, the interventions have taken the form of persuasive messages. Considered when designing a persuasive message are the audience, the message source, the medium used to present the message in addition to the message arguments and evidence. Persuasive messages constructed by science educators have followed guidelines described by Fishbein and Ajzen (1980) and Stutman and Newell (1984).

The first to make use of the guidelines was Chen (15). The initial step in his construction process was to gather responses from a sample of the projected audience about the advantages and disadvantages they associate with their teaching about the environment to young children and people who would approve or disapprove of them doing so. Content analysis of the responses, which involved grouping similar responses and counting

frequencies, resulted in lists of personal and normative beliefs. Data gathered from the same sample of the projected audience revealed that attitude contributed more to the prediction of intention than did subjective norm. By applying Ajzen and Fishbein's (1980) interpretation of regression weights as the relative importance of the model component, Chen chose the salient personal beliefs as the sole focus of his messages. Thus, eight behavioral beliefs representing better than 75 percent of the statements written by the sample were selected to be addressed in the messages. If supportive of the teaching about the environment, the belief was reinforced. If non-supportive, it was attacked or an attempt was made to change its evaluation from negative to positive. Both messages were attributed to an environmental expert and presented in four and one-half pages of printed text. They differed in that arguments in one were anecdotal while the other included summaries of statistical data. A validation check confirmed that the eight beliefs are addressed in the messages and that the arguments are supportive of the desired behavior.

Goddard (18) and Koballa (19) built messages using the same procedure as Chen. Goddard's message was designed to encourage nursing students to care for quadriplegic patients, while Koballa's focused on elementary teachers' intentions to teach energy conservation practices to children. Both researchers chose, as Chen did, to design their messages to address only behavioral beliefs and to be read by their audiences.

Other message development efforts attended to normative and control beliefs and refined the procedures pioneered by Chen. The focus of messages built by Crawley and Koballa (17) and Black (14) was the enrollment of Hispanic-American high school students in elective chemistry. The expectancy-value formulations of attitude, subjective norm, and perceived behavioral control influenced the way in which message arguments were crafted. "Information presented in the messages reinforced favorable attribute-behavior links [and discredited unfavorable ones]. Attributes consisted of specific outcomes, referents, or controls associated with engaging in the behavior, viz., signing-up for chemistry. Outcome-behavior links are called behavior beliefs; referent-behavior links, normative

beliefs; and control-behavior links, control beliefs" (17) . Crawley and Koballa built two messages; one for students and a second for the students' parents. In both messages, four advantages associated with enrolling in chemistry were reinforced, while two disadvantages and six perceived conflicts were downplayed or discredited. The communicator for both messages was a Hispanic-American female enrolled in a graduate program in science education, and the parent message was written in English and Spanish. An audiotape version of the student message was also developed so that poor readers could listen to the message as they read. The voice on the audio-recording was that of the female, Hispanic-American graduate student.

Black (14) developed messages for urban Hispanic-American students and their parents. She added to the design by carefully attending to the audience's prior knowledge. Prior knowledge favorable to the behavior was supported and validated in the messages, while knowledge deemed unfavorable was downplayed or counterargued. Black also made a concerted effort to incorporate concrete examples into her messages to support favorable and downplay unfavorable beliefs. Her messages took the same form as those prepared by Crawley and Koballa; however, a female, Hispanic-American biochemist served as the source of the messages. In all, Blacks' messages addressed nine personal, five normative, and ten control beliefs.

Warden (20) also developed a persuasive message using the same basic strategies. The source of Warden's message was a medical doctor with responsibilities for AIDS prevention in the local community, and the message was presented via videotape. The message was preceded by a focusing task that offered students a hypothetical but real-life situation about an encounter with a classmate who has just been diagnosed as HIV-positive. The task was designed to affect students' processing and evaluation of the message argument. A message summary sheet was also prepared to help students attended to salient arguments as they viewed the videotaped message.

Assertion 6. One's motivation to engage in a science-related behavior

can be affected by an intervention that targets personal, normative, or control beliefs about the behavior.

Persuasive messages were tested to determine their effects on persons' motivation to engage in diverse science-related behaviors. In these studies, motivation was operationalized as behavioral intention that according to the theories of Ajzen and Fishbein is the direct antecedent of behavior. Implicit in the use of persuasive messages is the choice of the recipient to accept to reject the appeal (Koballa, 1992).

Chen's (15) test revealed that the anecdotal message was superior to the data-summary message in changing attitudes and intentions. When examining the effects of the messages on behavioral beliefs and outcome evaluations, the antecedents of attitude, Chen found that the two messages were equally effective. The belief changes were retained to the end of the study three weeks after the treatment. Goddard (18), who compared a message built using strategies consistent with the theory of reasoned action with one that included arguments and evidence drawn from the nursing literature, found no difference between the two. Her finding failed to support the superiority of the message construction strategies recommended by Ajzen and Fishbein and Stutman and Newell.

Warden's (20) videotaped message attended to personal, normative, and control beliefs. She compared her message with two others, one that included arguments and evidence drawn from the popular AIDS literature and a placebo that addressed the topic of teenage acne. Her results revealed substantial gains in attitude for both experimental messages, with only arguments based on salient personal beliefs maintained to the end of the experiment four weeks later. Warden also found that the interaction of focusing task and degree of prior knowledge led to significant gains on subjective norm, but not significant differences among the treatments on student intention to volunteer to become the laboratory partner of a classmate who has AIDS.

Black's (14) results and those of Crawley and Koballa (17) provide stronger support for the effectiveness of belief-based persuasive messages that make use of the tenets of Ajzen

and Fishbein's models. Black reported that students' intentions to enroll in high school chemistry were significantly affected when both students and parents read the same belief-based message. Crawley and Koballa's results indicated that providing students, but not students and parents, with information about signing-up for chemistry increased enrollment.

Measures of Model Variables.

Assertion 7. Open-ended questionnaires can be constructed and used to generate data about personal, normative, or control belief about engaging in science-related behaviors.

The first to construct an open-ended questionnaire to identify students' personal and normative beliefs that underlie a science-related behavior was Stead (13). His questionnaire was constructed by adapting items described by Ajzen and Fishbein (1980). One of the items on his questionnaire that focused on personal beliefs asked, "What are the advantages, for you personally, in studying science in the Fifth form"? (p. 79) Responses to the questionnaire resulted in eight personal beliefs and two normative beliefs; both sets of beliefs were considered salient for the students.

Koballa's (9) and Crawley and Coe's (6) descriptions of the questionnaire construction process and the resulting data were more detailed. Koballa constructed nine questions to gather data from a subsample of eighth graders about their enrolling in high school physical science courses. Students' responses resulted in 84 personal belief statements and 77 normative belief statements. These responses were grouped, and some groups were collapsed to produce 13 personal belief categories and nine normative belief categories. Sorting of the statements by others verified Koballa's categories. Crawley and Coe identified eleven personal and seven normative belief categories using the same procedure. Preparing for college and learning new information were among the personal belief categories formed regarding high school science enrollment, while normative belief categories included family members, future employers, and close friends. In both efforts, the categories were considered modal salient beliefs for the groups of students studied and

accounted for 75 percent or more of the responses written.

Other studies used the same procedure to generate personal and normative belief data (2, 3, 11, 15, 8, 19), while several made minor modifications to accommodate the addition of control beliefs (4, 12, 14, 16, 17). All were successful in using the recommendations of Ajzen and Fishbein to develop open-ended questionnaires and to employ them to generate belief data. In addition to revealing much about the groups questioned, these data were then used to build persuasive messages or structured instruments.

Assertion 8. Personal, normative, and control belief data can be content analyzed using hierarchical modelling to identify students' and teachers' modal salient beliefs about engaging in science-related behaviors.

Koballa and Meadows (21) used hierarchical modelling to analyze teachers' beliefs about joining the National Science Teachers Association (NSTA). Hierarchical modelling is the systematic, qualitative process of developing hierachies of belief categories. Belief data were collected from 40 preservice elementary teachers using an open-ended questionnaire, and belief categories were generated to represent multiple responses as had been done in previous studies. Three advantages of the hierarchical modelling procedure over the content analysis procedure were revealed in the study:

- Due to the hierarchy's visual display, category linkages are easily seen.
- The hierarchy's layered arrangement reveals belief specificity, facilitating the generation of more encompassing and meaningful categories.
- Identifying the categories that represent a majority of respondents and those generated by the researchers is made easy by the placement of numbers beside the category labels.

The study also revealed that the hierarchical analysis procedure does not overcome the need to interpret some responses and problems of redundant responses. Attempts to extract meaning from ambiguous responses became problematic when interpretations influence the frequency of categories and the labels given them. Redundancies were found for responses

to questions about the advantages of joining NSTA and factors that would encourage the respondent to join the organization. Eliminating or revising one of the pair of questions was recommended by the researchers. The study's contribution is its description of a strategy that can be used when attempting to understand the relationships among modal salient beliefs that function as the antecedents of science-related behaviors.

Assertion 9. Modal salient belief can be used to construct closed-ended questionnaires that provide information about the factors that affect individual student's and teacher's motivation to engagement in a science-related behavior.

Closed-ended questionnaires provided information about model variables in all the studies identified in Table I except the one in which Koballa and Meadows explored the uses of hierarchical analysis. Modal salient belief statements were generated from a sample of the target audience. They were then used to write belief items and corresponding evaluation items that appeared on the closed-ended questionnaires designed for the different studies. Items that appeared on the instrument used by Myeong (10) are presented below:

Attitude

Behavioral Belief:

My choosing the science track will help me find a job that I will like.

likely (a) extremely (b) quite (c) slightly (d) neither (e) quite (f) slightly (g) extremely unlikely

Outcome Evaluation:

Finding a job that I will like is

good (a) extremely (b) quite (c) slightly (d) neither (e) slightly (f) quite (g) extremely bad

Subjective Norm

Normative Belief:

My parents think I _____ choose the science track.

should (a) extremely (b) quite (c) slightly (d) neither (e) quite (f) slightly (g) extremely should not

Motivation to Comply:

Generally, speaking, I want to do what my parents think I should do.

likely (a) extremely (b) quite (c) slightly (d) neither (e) quite (f) slightly (g) extremely unlikely

Studies based on the theory of planned behavior included items to measure the antecedents of perceived behavioral control. The first product of these efforts included items to assess control beliefs only. The label, factor's frequency of occurrence, was used by Coleman, Koballa, and Crawley (16) to identify these items. Construction efforts that followed adopted an expectancy-value formulation for the antecedents of perceived behavioral control. This action, first taken by Crawley and Koballa (17), resulted in items like those found on Wardens' (20) questionnaire.

Perceived Behavioral Control

Control Belief:

My feeling sorry for a person with AIDS would help me volunteer to become the laboratory partner of a classmate who has AIDS.

likely (a) extremely (b) quite (c) slightly (d) neither (e) quite (f) slightly (g) extremely unlikely

Frequency of Occurrence:

Feeling sorry for a person with AIDS is

good (a) extremely (b) quite (c) slightly (d) neither (e) slightly (f) quite (g) extremely bad

Further refinements included restructuring the format of outcome evaluation and motivation to comply items to conform to a 7-point, likely-unlikely response scale. The refinement lessened respondent confusion when reading items (17).

Items were also written to assess attitude, subjective norm, perceived behavioral control, and intention, as prescribed by Ajzen and Fishbein (1980). Each item was followed by a 7-point, likely-unlikely response scale. Few changes were made to these items over the course of the studies, and none resulted in significant improvements. One such change was Crawley and Koballa's (17) addition of an evaluation counterpart to intention, subjective norm, and perceived behavioral control items. This change was made to test the hypothesis that an expectancy-value formulation of each variable would increase its correlation with other model variables. Items that reflect this change are shown below.

Intention: I intend to sign-up to take chemistry in September, 1990.

likely (a) extremely (b) quite (c) slightly (d) neither (e) quite (f) slightly (g) extremely unlikely

Intention Evaluation: When I make up my mind to do something, I do it.

likely	(a)	(b)	(c)	(d)	(e)	(f)	(g)	unlikely
	extremely	quite	slightly	neither	quite	slightly	extremely	

Researchers' Reactions to the Assertions

In addition to the two authors, twelve others were directly involved in the research studies that served as the primary data base for this work. Each was asked to react to the nine assertions as they applied to the study or studies in which he or she was involved. Specifically, the researchers were supplied with a copy of the assertions organized into three categories—measures of model variables, intervention design and implementation, and behavioral prediction. They were asked to read the list, to "put a big 'X' to the left of all the assertions that you believe apply to the study highlighted on the list," and to return the list of assertions with any comments in the stamped, self-addressed envelope provided. Four marked assertion sheets were returned after six weeks, all from individuals employed at U. S. colleges or universities. No sheets have been returned by the three individuals residing outside of the U.S. Telephone calls to nonrespondents in the U.S. indicate that reasons for not returning the assertion lists should not significantly alter the results reported here.

Analysis of the marked assertion sheets and respondents' comments revealed patterns that support the tenets of the nine assertions. Two assertion sheets were returned from persons whose studies attempted to predict and understand why individuals engage in certain science-related behaviors. Assertions marked fell under the headings of "measures of model variables" and "behavioral prediction and understanding." No marks appeared next to the assertions concerning intervention design and implementation. As one researcher stated, "Does not directly apply to the study indicated because there were no results from intervention. However, assertion 5 could have been made as a suggestion for further research."

The other two assertion sheets were returned from researchers who constructed and

tested persuasive messages. Marks were placed beside assertions grouped under all three headings. One assertion sheet reflected the advances made since the study was completed; qualifications were offered regarding the use of control beliefs that were not considered by the theory of reasoned action, the model that guided the study. Other comments described findings that were inconsistent with the model that directed the work. One researcher wrote about an assertion found under the heading Measures of Model Variables, "I think my study ran into a problem here!! But theoretically, it should be possible."

The returned assertion sheets also revealed some confusion about Assertion 8 regarding the use of hierarchical modelling to identify modal salient beliefs. As intended in the assertion, hierarchical modelling refers to the qualitative strategy of developing a hierarchy of belief categories, where the higher levels of the hierarchy subsume the categories displayed below. Since the researchers who marked this assertion were not involved in the lone study that employed this strategy, it must be concluded that for them the term hierarchical modelling has another meaning. The common aspects of the studies in which the two researchers were involved suggests that to them hierarchical modelling is the statistical process whereby belief categories are eliminated from a regression equation if they fail to make a significant contribution. Follow-up interviews with these respondents should serve to verify or refute this hypothesis.

One respondent enclosed six pages of comments with the assertion sheet. The comments hit upon three areas related to the study that deserve mentioning. One was about the need to define the term assertion. "Although you have not defined assertions, I am assuming that they are a little stronger than assumptions, but personal to your teaching field." A second concerned the trust put in self-report data by those who base their research on the theories of reasoned action and planned behavior. A final comment indicated that actions of students and teachers were not addressed in the assertions. This final comment revealed an oversight and prompted a reexamination of the studies for behavioral data. That reexamination led to the following statement.

The likelihood that one will engage in a science-related behavior is determined by the person's motivation to do so. According to Ajzen and Fishbein (1980), behavioral intention can be thought of as one's personal motivation to act. Three studies looked at the relationship between intention and actual behavior. Crawley and Koballa (17) investigated Hispanic-American students' enrollment in high school chemistry, while Shaffer (12) examined college students' success in an undergraduate computer science course, where success was operationalized as a grade of C or better. Both studies reported that intention accounted for 10 percent of the variance in behavior. Myeong's (10) study of Korean students' science track choice provided stronger results. Tenth graders in Korea "are expected to select the general direction of their future career by choosing either the 'humanities (and social science) track' or the 'science track'"(p. 9). Using the computer statistical program LISREL, she found that intention explained 56 percent of the variance in boys' choices and 37 percent of the variance in girls' choices.

Summary

The theory of reasoned action is a social psychological model that was first considered by science educators in the early 1980s to investigate attitude-behavior relationships. Following from the theory, two factors affect the relationship between attitude and behavior. One is the extent of agreement between the measure of attitude and the actual behavior. To assure agreement, Ajzen and Fishbein (1980) recommended that an attitude object and its measure match the behavior of interest in terms of action, target, context and time. The second factor concerns the impact of referents on behavior and how to measure their influence.

The variable recommended for use with attitude is subjective norm. Subjective norm is the perceived social encouragement or discouragement to perform the behavior. Normative influences for children and adolescents include parents, teachers, siblings, and friends. Individual attitude and subjective norm scores are algebraically combined to produce a behavioral intention score. This score is identified as the best predictor of behavior.

Variables not a part of the model are considered to affect behavior only indirectly through their influence on attitude and subjective norm.

The theory of reasoned action has a weakness; it cannot deal with behaviors that are nonvolitional. Ajzen's (1985) remedy, presented as the theory of planned behavior, was to add to attitude and subjective norm a third antecedent of behavioral intention called perceived behavioral control. Perceived behavioral control is the perceived resources and opportunities that make performing the behavior possible or impossible. Perceived control rather than actual control is appropriate here since a person can only speculate about events likely to facilitate or inhibit behavior before acting. Beliefs that control punctual, daily school attendance, for example, are a high school student's concerns about having a flat tire while driving to school or falling asleep after shutting off the clock radio alarm.

A strength of the combined theories is that they provide guidance for the development of persuasive messages. "Persuasion is considered to be mediated by cognitive processing and is contemplated in light of expectancy-value formulations of attitude, subjective norm and perceived behavioral control" (Koballa, in press). The expectancy-value formulation for attitude was unveiled twenty years ago by Fishbein (1963) to illuminate his conception of the relationship between attitude and beliefs. "In the language of the expectancy-value theorem," according to Crawley and Koballa (1991), "a person's attitude toward any object is a function of the beliefs the person holds about the object and the implicit evaluative responses associated with those beliefs." Like attitude, subjective norm and perceived behavioral control are also presented as linear combinations of salient beliefs (cognition) with each belief weighted by its value (evaluation). These expectancy-value formulations communicate the cognitive processing that takes place prior to decision-making (Crawley & Koballa, 1991).

Instrument development and message design using the theories of Fishbein and Ajzen have the same point of origin. Both start with gathering data about the behavior from a sample of the target audience. Beliefs about the behavior are sought using a set of three of

questions:

What do you see as the personal advantages and disadvantages of performing the behavior?

Who are the people who approve or disapprove of your performing the behavior?

What things could occur to make it easier or more difficult for you to perform the behavior?

Responses are grouped and counted to identify the most frequently mentioned outcomes, referents and control factors. These are considered modal salient beliefs and are used in designing scale items and message arguments.

A standard format is used for constructing items to assess the model constructs of behavioral intention, attitude, subjective norm and perceived behavioral control. Only the description of the behavior is altered to correspond with the intended use of the instrument. The four model constructs are measured using 7-point, sematic-differential scales. Also measured using sematic-differential scales are the beliefs and evaluations that function as the antecedents of attitude, subjective norm and perceived behavioral control. The belief statements and their corresponding evaluation statements are constructed from responses gathered using the set of questions shown above.

A persuasive message is built by using the modal salient beliefs to construct arguments that are supportive of the desired behavior. Guided by the work of Stutman and Newell (1984), Crawley and Koballa (1991) recommended that beliefs supportive of the desired behavior be reinforced and that non-supportive beliefs be downplayed or, if possible, discredited. In addition, the relationship between each supportive belief and its evaluation should be strengthened, while each non-supportive belief should be disassociated from its evaluation. When writing arguments that operationalize these recommendations, numerous sources of information should be consulted.

Overall, the findings provide strong support for the utility of the theories of reasoned action and planned behavior. The theories can be used by science educators to investigate a

variety of science-related behaviors and the antecedents of these behaviors. The strength of the theories as indicated by the assertions lies in their abilities to help science educators to predict, understand, and modify the science-related behaviors of students and teachers.

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Table 1

Studies that utilized the theory of reasoned action or theory of planned behavior.

Behavioral Prediction and Understanding

1. Arditzoglou, S. Y. (1991). *Structural equation modeling of science and mathematics achievement of secondary I female Palestinian students in Arab Jerusalem.* Unpublished doctoral dissertation, University of Texas at Austin.

2. Crawley, F. E. (1988). *Determinants of physical science teachers' intentions to use investigative teaching methods: A test of the theory of reasoned action.* Paper presented at the 61st annual meeting of the National Association for Research in Science Teaching, Lake of the Ozarks, MO.

3. Crawley, F. E. (1990). Intentions of science teachers to use investigative teaching methods: A test of the theory of planned behavior. *Journal of Research in Science Teaching, 27,* 685-697.

4. Crawley, F. E. (in press). Causal modeling of secondary science students' intentions to enroll in physics. *Journal of Research in Science Teaching.*

5. Crawley, F. E., & Black, C. B. (1990). *Attitude and secondary school science students' intentions to enroll in physics: An application of the theory of planned behavior.* Paper presented at the 63rd annual meeting of the National Association for Research in Science Teaching, Atlanta.

6. Crawley, F. E., & Coe, A. E. (1990). Determinants of middle school students' intentions to enroll in a high school science course: An application of the theory of reasoned action. *Journal of Research in Science Teaching, 27* 461-476.

7. Koballa, T. R., Jr. (1988). *The determinants of eight-grade students' intentions to enroll in elective science courses in high school.* Paper presented at the 61st annual meeting of the National Association for Research in Science Teaching, Lake of the Ozarks, MO.

8. Koballa, T. R., Jr. (1986). Teaching hands-on science activities: Variables that moderate attitude-behavior consistency. *Journal of Research in Science Teaching, 23* 493-502.

9. Koballa, T. R., Jr. (1988). The determinants of female junior high school students' intentions to enroll in elective physical science courses in high school: Testing the applicability of the theory of reasoned action. *Journal of Research in Science Teaching 25,* 479-492.

10. Myeong, J. O. (1990). *Predicting and understanding Korean high school students' science track choice: Testing the theory of reasoned action by structural equation modeling.* Unpublished doctoral dissertation, University of Texas at Austin.

11. Ray, B. D. (1989). The determinants of grade three to eight students' intentions to engage in laboratory and nonlaboratory science learning behaviors. *Journal of Research in Science Teaching, 28,* 147-161.

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15. Chen, C. S. (1988). *Cognitive style and intention change: The effects of anecdotal and data-summary persuasive strategies on teachers' intentions to teach about the environment.* Unpublished doctoral dissertation, University of Texas at Austin.

16. Coleman, D. C., Koballa, T. R., Jr., & Crawley, F. E. (1992). TLTG Interactive videodisc physical science program: Interest results of the 1988-89 field test. *Journal of Educational MiltiMedia and HyperMedia., 1*, 234-245

17. Crawley, F. E., & Koballa, T. R., Jr. (1990). *Hispanic students' interest in chemistry project: Final report for the Pharr-San Juan-Alamo Independent School District.* Unpublished report, Science Education Center, University of Texas at Austin.

18. Goddard, L. R. (1990). *Interaction of type of persuasive message (traditional vs. Fishbein and Ajzen) and the method of cognitive elaboration on behavioral intention, attitude and subjective norm related to caring for quadriplegic patients.* Unpublished doctoral dissertation, University of Texas at Austin.

19. Koballa, T. R., Jr. (1989). Using salient beliefs in designing a persuasive message about teaching energy conservation practices to children. *Science Education, 73*, 547-567.

20. Warden, M. A. (1990). *The effect of two videotaped persuasive messages on 7th grade science students' intentions to perform an AIDS-related laboratory behavior.* Unpublished doctoral dissertation, University of Texas at Austin.

Instrument Development

21. Koballa, T. R., Jr., & Meadows, L. (1991). *Beliefs about joining a professional science teachers organization.* Paper presented at the annual meeting of the Southeastern Association for the Education of Teachers in Science, Wakulla Springs, FL.